Machine vision diagnosis of eyes for vitamin A conditions in Japanese black cattle(Digest_要約)

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Summary

Marbled meat (containing intramuscular fat running through it) is the most influential factor determining the grade quality of beef in Japan. To produce beef with higher marbling, Japanese black cattle farmers actively manipulate the serum vitamin A to a minimum desired low level (about 30 IU/dL) during fattening of the cattle. However, serum vitamin A levels below a certain condition can increase disease susceptibility. Therefore, it is important to monitor vitamin A conditions during this fattening period to avoid cattle from contracting serious diseases. At present, a blood assay is the conventional way to measure serum vitamin A level in cattle. However, it is costly, invasive, time consuming and can be stressful for the cattle. Thus, an alternative blood assay was investigated: a machine vision diagnosis system of cattle eyes, in order to help farmers more readily monitor vitamin A deficient (VAD) levels of Japanese black during the fattening period.

Chapter 2 briefly summarized the ocular changes caused by vitamin A deficiency reported in literature and some sample images of eye diseases were shown for a better understanding of ocular changes. Besides that, the optical properties of lens and vitreous humor of cattle eyes were measured and shown.

Based on the knowledge of Chapter 2, the relation between serum vitamin A level and three aspects (pupil color, pupillary light reflex and light reflection) were investigated individually. These three aspects were selected because they were easy to be extracted from the images acquired by a customized machine vision system.

In Chapter 3, we studied color changes of pupil area in Red, Green, Blue (RGB) and Hue, Saturation, Intensity (HSI) color models from July to November in 2010 and from May to December in 2011 to estimate the serum vitamin A levels of Japanese black cattle during their vitamin A controlled stage. The result showed there was a negative tendency between the red component ratios and serum vitamin A levels. The

relative high red component ratio during the low vitamin A period may indicate the mottled appearance of the non-tapetal area. This knowledge maybe used as a guide for farmers. In 2011, a multiple linear regression model was built based on the data from 24 cattle with a wider range of serum vitamin A levels. The model had an estimation error about 10 IU/dL. Even though the model may not work well with other eye images, it showed the potential of this method.

In Chapter 4, to study the relationship between pupillary light reflex (PLR) and serum vitamin A levels, an image processing algorithm, based on least squares ellipse fitting, was developed and successfully applied to the pupil area of cattle eyes. Compared with the manually selected result, the root mean square errors of pupil area and constriction amplitude (*CA*) were 930 pixels (The whole image pixel number is 786432) and 2.3%, respectively. PLRs was investigated from May 2011 to December 2011 and from June 2012 to February 2013 with two different groups of cattle. In 2011, Japanese black cattle in low vitamin A level period showed significant larger *CA* in 1 second and significant smaller *IPR* value. In 2012, two sample *t*-test and paired *t*-test showed there were no significant difference ($p>0.05$) in *CA* between low and high vitamin A group cattle. However, two cattle were identified weak PLR (*CA*<10%). On the other hand, compared with cattle in high vitamin A stage, there were more cattle possessed smaller initial pupil roundness (*IPR*) ($p<0.05$) in a dark environment during vitamin A deficient stage in two years.

In Chapter 5, five parameters (*r, I, CA, IPR, I_RFL*) extracted from pupil color, pupillary light reflex and light reflection analysis, were used to classify fattening cattle into the mild (67-100 IU/dL), moderate (33-67 IU/dL) and severe (0-33 IU/dL) VAD groups in 2011. Multivariate classification methods, soft independent modelling of class analogies (SIMCA) and partial least squares discriminant analysis (PLS-DA) were used. The mild and severe VAD groups could be classified with over a 85% correct classification rate. A VAD index was designed and proved to be effective in representing vitamin A conditions. The results demonstrated the potential for ocular changes to be utilized for non-invasive estimation of vitamin A conditions.

Chapter 6 summarized the main contributions of the works, and explained current limitations and future works.